VOLUME XLI NUMBER 6 WHOLE NUMBER 365

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR, C. A. CHANT ASSISTANT EDITOR, F. S. HOGG

David Dunlap Observatory
Richmond Hill P.O., Ont.

ASSOCIATE EDITORS:

C. S. BEALS
Dominion Astronomer
Ottawa

J. A. PEARCE
Dominion Astro-physicist
Victorio, B.C.

A. THOMPSON
Controller of the Meteorological Service of Canada, Toronto

PUBLISHED MONTHLY
(*Ten numbers per year*)

July-August, 1947

PRINTED FOR THE SOCIETY
TORONTO: 3 WILLCOCKS ST.

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

VOL. XLI, No. 6 JULY-AUGUST, 1947 WHOLE No. 365

Articles PAGE

On the Surface Features of the Moon—A Review of Ingolf Rund's Theory ..... *T. S. Jacobsen* 209

Erecting Star Diagonals ..... *F. K. Dalton* 225

Sidereal and Solar Time ..... *H. Boyd Brydon* 229

Out of Old Books

Derham's Catalogue of Nebulous Objects from Hevelius' Prodromus ..... *Helen Sawyer Hogg* 233

Review of Publication

Making Your Own Telescope, by Allyn J. Thompson; Nuestro Maravilloso Universo, by C. A. Chant ..... *F.S.H.* 238

Notes and Queries

History of "Notes and Queries" (*C.A.C.*); Note regarding John Couch Adams (*C.A.C.*); In Time and Eternity (Poem by Averil Morley) 240

Meetings of the Society

At Toronto—At London 243

Upon request, made previous to publication of article, contributors will be supplied free with twenty-five copies of the sheets containing the article attached to a printed cover.

Extra copies about as follows:

	4 pp.	8 pp.	12 pp.	16 pp.	20 pp.	24 pp.
50 copies	$3 50	$5 50	$9 50	$10 00	$13 00	$16 00
100 copies	4 00	7 00	10 00	11 00	14 00	18 00
200 copies	4 50	8 00	11 00	12 00	15 50	20 00

Covers, extra, 50 copies, $1.50; 100 copies, $2.00; 200 copies, $2.50.

Address of Editors: David Dunlap Observatory, Richmond Hill, Ontario.

Business correspondence, remittances, etc., should be addressed to J. H Horning, Treasurer of the Society, 3 Willcocks St., Toronto 5, Ontario.

$2.00 per annum. Single numbers, 25 cents.

Subscription to the JOURNAL is included in membership fee.

NOTICE FROM THE GENERAL TREASURER

Those who have already received the OBSERVER'S HANDBOOK for 1947, but are intending to resign their membership at the end of 1946, are asked to send the 25c payment (coin in card) to their local treasurer or to the General Treasurer, 3 Willcocks St., Toronto 5.

PRINTED IN CANADA

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY
OF CANADA

VOL. XLI, No. 6 JULY-AUGUST, 1947 WHOLE No. 365

ON THE SURFACE FEATURES OF THE MOON*

A Review of Ingolf Ruud's Theory

By T. S. JACOBSEN

ASTRONOMICAL authors of papers on the origin of the moon's surface features have often neglected to take full advantage of what has been published by the real experts on this subject, the geologists and the physicists. While proponents of the meteoritic theory generally have acceptable physical concepts, their papers are often abortive in that they pay too little attention to the details of crater arrangement and description of lunar forms, and yet an excellent memoir published in 1903 by the well known geologist N. S. Shaler, supplies this information.[1] Adherents of some modern version of the igneous theory, while usually arguing more directly about the details of the forms, would often do well to save their powder until after a study of the ordinary tectonic forces certainly active in the moon have received full attention. Those forces have recently formed the basis for a tectonic theory of lunar surface features. It seems that one of the most important papers on this subject, by Ingolf Ruud,[2] has received far less attention than it deserves. The value of a theoretical paper in applied science is increased if, subsequent to being written, it freely relates to many observed facts not considered specifically in its making. Since Ruud's paper produces relevance of a new kind among observational facts presented by Shaler and others, it is worth while to present

*Condensed from a lecture given before the Victoria Centre of the Royal Astronomical Society of Canada, August 26, 1946.

a summary of his work, prefaced by some physiographic description of the lunar surface. The present author claims no originality for possible 'new explanations'. It is but natural that such may appear in the description and integration of almost any subject. Quotations have been used freely, and in the descriptive part of this account no attempt has been made to do away with the old evolutionary time order of the lunar formations, although the Ruud theory requires its total reversal in most cases.

Older Descriptions of the Lunar Surface

In choosing between the various theories of lunar features, it is the fine details of the surface which are to-day decisive. The existence of domes (called laccoliths in a recent paper)[3] on the floors of the maria, the straight or curvilinear arrangements of thousands of craterlets in groups of from three to near fifty, the complex structure of the rays—all must be considered in discussing the agency of the formation of the surface features. A very valuable source of detailed information is the set of drawings by Philip Fauth made with his two telescopes of 6-inch and 7¼-inch apertures, published in his book, "The Moon in Modern Astronomy." In lunar observations the details obtainable visually with a 7-inch telescope often equal or exceed those visible on the best photographs taken with much larger telescopes, which are nearly always limited by the size of the silver grains of the photographic plate. The value of Fauth's work lies in the patience with which he has observed lunar forms at various inclinations of the sun's rays to the lunar surface and clearly delineated their smallest details. His drawing of Gassendi suggests, not a crater, but a circular system of mountain ranges. We shall see later that this viewpoint applies generally to the larger craters, ring plains, mountain rings, walled plains, and circular maria, because of the relative shallowness of all these structures.

Some typical quotations from Fauth follow:

> The lunar plains are seen under good illumination to be very much dented, veined, granulated, and torn. In many places isolated peaks and hills rise abruptly from the surface without any gentle slopes at the foot. There are small plateaus rising from flat ground, and an incalculable number of large and small structures scattered over it. Taking them as a whole, these level plains follow the general surface of the moon, but there seem to be round protuberances

of almost imperceptible slope and baseline, and flat depressions with indefinable shores. They do not cast shadows. There are some cases where flattish eminences lie much like thin disks on the floor of the moon;—they generally have a little crater inside them.

Hardly has the sun risen over a particular region than the first trace of the brighter streaks appear. The structure is already there, and is generally clearly recognizable in the earthshine of the new moon. As the sun advances the streak of light is defined more and more against the different tones of the floor, and finally shines with an almost pure white, remaining visible, and paling but little until it sinks into the lunar night. Even at the terminator, where the flattest hillocks with no measurable slopes are indicated by a half-tone, the floor of the moon that bears these rays does not show any elevation. What is called a ray is not one continuous object but the effect of the accumulation of spots and lines. The arrangement of these in longitudinal directions concentrated around a ring mountain is a system of rays. There are two main species of rays, the Tycho ray, and the Copernicus ray. The first is long and straight, the second short and curved. In each case they are centred on the mountain. As regards the Tycho type, also found around Kepler, one distinctive feature is the great distance from the centre to which it can be followed. In the case of Tycho the finest lines run rather at a tangent to its eastern and south-eastern walls, and many sheafs, that run towards the west, take their origin and direction from the southern wall. In number there must be about fifty lines without counting the fine brush-like ramifications. In the Copernicus type also some of the lines start from inside the mountain ring, and some from its encircling wall.

The essential value to-day of Shaler's work lies in its clear descriptions of a physiographic nature and in his qualified judgment of the lack of similarity of any lunar formations to lava flows on the earth. To continue with the physiographic picture we quote Shaler. In the quotations it should be kept in mind that the terms in the language suggesting igneous or volcanic processes are used to-day only for the sake of preserving his vividness of description:

On the maria there are many irregularities, as, for instance, the multitude of more or less continuous low arched ridges, probably in no instance more than 2000 ft. high, but uniformly of relatively great width, often several miles in transverse section. The ratio of the number of craters on the maria to the number on an equal area of the original surface, is about one to five, and (with few exceptions) their average size is in about the same proportion. It is also to be noted that rifts or open cracks are apparently rarer on the maria than on the highlands and that the light bands and patches are of relatively seldom occurrence... There are some thirty ray systems, and more than 2000 rills.

Many lunar volcanoids have a linear arrangement. The instances of linear or curvilinear arrangement become more numerous as the structures considered are of smaller diameters. For craterlets the linear arrangement becomes so

common that the exceptions are rather to be found in departures from it. According to Pickering there are evidences of a causal relation between the smaller visible pits and the cracks that form on the surface. There are thouands of the smaller craterlets which are disposed in lines, some of the series extending for hundreds of miles. There are some hundreds of lines of pits, a number sufficient to make it evident that they cannot be accounted for by chance. Near Mare Crisium, the crater Burchardt has two deformed craters beside it. These features seem to have been produced by some compressive action due to the formation of Burckhardt. East and south-east of Burckhardt there is a remarkable confusion of deformed volcanoids. In large walled plains there is no great difference between the outside and the inside of the walled plain. Minor craters, cones, and ridges on the floors and rims of larger walled plains are abundant in proportion to the area and age of the structure. There are thousands of craterlets, with no distinct wall or cone surrounding the pit, the opening often being abrupt as if brought about by a mere subsidence of the area in which it lies. Yet in sundry instances there are traces of ring walls as if some material had been extruded. In many instances these pits are not circular, but have irregular outlines, which suggests that in certain cases there were no explosive discharges, but an infalling of the covering of a pre-existing cavity. It is to be noted that these craterlets often, perhaps oftenest, lie upon ridges, either the walls of the larger volcanoids, or the numerous elongate elevations which occur in great numbers on various parts of the surface. The presence of a level surface of frozen lava in all parts of the lunar volcanoids save perhaps the very smallest is, as compared to the earth their most conspicuous feature. We are justified in regarding the level interiors as evidence that the normal lunar crater did not discharge explosively in true volcanic fashion. We have other evidence to the same effect in thousands of cases in the lack of all signs of ejected masses of dust-showers, such as are the most striking phenomena of terrestrial outbreaks. In many instances I have observed that there was no trace of ash-covering up to the very foot of the ring wall. Like evidence of a more confirmative nature is to be had in the numerous instances in which one volcanoid cuts another. The earlier existing crater, except where its walls have been deformed by the encroachment of its neighbour, never suffers any distinct obliteration. Its ring wall, craterlets, vents, terraces, and other slighter features, which would be hidden or distinctly changed in aspect by the accumulation of even a few score feet of ash, remains, as far as can be discerned, unaltered. When we remember that there has evidently been no erosive action on the moon such as has normally washed away thousands of feet in thickness of ash about Aetna and other large terrestrial volcanoes, we see how clear is the evidence that the lunar volcanoids have not been the seat of ordinary volcanic explosions.

The lack of lava flows appears to be almost as well established as the absence of ash slopes. In the few instances where structures which can possibly be classed as flows of fluid matter proceeding from craters have been suspected, closer inspection makes the explanation more than doubtful. None of the rills

or other fractures appears to have afforded passage to fluid material, they seem, indeed, to have been formed long after the larger volcanoids had ceased to be active. Although there are several regions where volcanoids are rare, it should be understood that these fields do not entirely lack volcanoids; it is indeed doubtful if there is any part of the moon's surface, except it be some portions of the maria, where craters of large or small size may not be found in every circle of twenty miles diameter. On the maria there is a greater proportion of the number of crater cones to craterlets than on the highlands... The phenomena of dilapidation exhibited by the relics of ring walls in the fields of the maria differ essentially from what we find on the outlying surface of the moon. In the last named areas, the ruining of the ancient ramparts has been in large measure brought about by the encroachment and possibly by some shearing pressure of later-formed volcanoids, which actions have broken down and shoved about the fragments of the once complete circumvallations. In addition to the processes of burial and displacement, there have apparently been at work some influences which have slowly broken down the rings, so that they have lost their original steepness. In and on the borders of the maria we find evidence that the destruction was brought about by the immediate and swift assault of the originally fluid material that now forms the plains of frozen lava. The rings are not deformed but more or less broken down, in part breached, by the stroke of a tide of fluid rock, as in the submerged unnamed ring north of Flamsteed. As we pass from the larger rings downward in a series towards the smallest craters which have distinct floors, we note a progressive increase in the freshness and finish of these structures. The departures from the original form become less frequent, the walls are less breached, and the slopes of the ramparts steeper and more even. The interference of rings of like size becomes rarer, so that with those less than five miles in diameter it does not occur. All these facts point to the conclusion that in general the larger the rings the greater their age. The first stage of volcanoid formation probably consisted in the production of a slight dome-shaped elevation such as abound on the lunar surface, being, indeed, the commonest of the smaller features on many parts of the area outside the maria. These dome-like elevations appear to be due to the accumulation of vapours beneath the superficial layers, formed perhaps when the whole crust was still partly softened by heat. At a certain stage of the process this arch fell in, or was broken to pieces and thrown outwardly, leaving a pit with lava in it.

The above quotations give a clear example of the kind of observed detail the explanation of which must be one objective of any acceptable lunar surface theory. Further observations on even finer details of a discriminatory nature, possible only with large telescopes, is suggested by Shaler in order to estimate to what extent weak eruptive action may combine with his otherwise composite theory. In spite of the apparent success of his above-quoted explanations, every process suggested,

with the possible exception of two, and the relative ages of most of the structures, are completely changed in the modern contraction theory. In the Ruud theory no falling bolides are postulated to account for the maria. All the known features are explained as the result of processes associated with the inevitable tectonic changes accompanying contraction of the crust. None of the surface features needs be volcanic in origin. They may or may not be igneous. All the processes are known from the earth, and the constants of the rocks are assumed to be very similar. The modifications in the conditions are such as might be expected on a globe of the size, shape, and density of the moon.

In order to appreciate the possibility of applying the tectonic theory to hard rock structures and to gain perspective of the scale of the phenomena contemplated, we need to rid ourselves of the popular but erroneous idea, that the typical ring plain is cup-shaped, or that its depth is a large fraction of its width. With the realization of the astounding shallowness of the larger surface features begins all acceptable interpretation of them as circular systems of mountains. A very thorough study of the profile of the typical ring plain Theophilus was made by McMath, Petrie, and Sawyer,[4] who in 1935 measured the lengths of the shadows on 800 successively exposed photographs, deriving a vertical cross-section along a diameter of this nearly 17,000-feet-deep crater. If their diagram be redrawn on equal scales for width and depth, one finds a ratio of width to depth of about 23 to 1. Neglecting small variations in steepness, the general slope anywhere on the contour is but 10°. At an earlier date Fauth found the ratio of depth to width for a number of structures to be as follows: Ptolemy, 0.65%; Clavius, Plato, 2%; Archimedes, 2.1%; Copernicus, 3.66%. Thus the deepest hole of the above group is far more shallow than a common saucer for which the ratio is above 10%. But inner slopes are in some cases appreciable. Average values of these for various diameters were found to be as follows: 11.°6 for walled plains above 60 miles in diameter, 14.°8 for ring mountains 30-60 miles in diameter, 22.°7 for walled rings 18-30 miles in diameter, 33.°5 for craters up to 18 miles in diameter. There are maximum slopes of 50°, but 'there are no vertical precipices or crater-walls on the moon.'

Characteristic Forms of Ruptures in Surfaces

The geophysical part of Ruud's work is based upon standard texts on geology and a modern text on plasticity.[5] In the original paper photographs are shown of a series of laboratory experiments performed by him on the invariable shapes of breaks formed in various membranes, of an elastic, plastic, or intermediate character; and also on structures formed in plastic masses gradually undergoing contractions and finally turning brittle. Unlike the common run of similar demonstrations on powders and bubbles, in which the main forces acting are irrelevant on the scale of mountain building, these experiments are to be regarded more as true analogies, because geologists have independently accepted the plastic properties of the rocks to be responsible for the characteristic features of an appalling number of different terrestrial flow processes taking place in nature on a scale ranging from near microscopic intrusions to the formation of the East Asiatic and Pacific island rims.

Fig. 1. Slit-like break in a strong elastic membrane cemented to a plastic membrane. (gold foil, rubber)

In these experiments the membrane to be tested is fastened to a circular metal ring. By means of equally-distributed weights a concentric ring of smaller diameter is pressed against a membrane, thus producing a system of equal radial tensions in the membrane. A powerful electric lamp adjustable at different distances in the axis of the rings renders the membrane translucent thus permitting a study of the flow lines in the material. The forces are increased until holes develop. Four main results are obtained from a study of holes grown under constant forces.

A. In a plastic membrane (rubber heated by the lamp) breaks appear in accidentally weak places. The flow lines extend to five times the diameter of the hole. The holes are at first angular, but round off quickly at the corners, and as they grow at different rates

and start forming at different times, the end product after five to ten minutes is a number of irregularly distributed holes of very different diameters. Unequally distributed tensions produce elliptical holes with the long diameter in the direction of maximum tension. The flow lines are not modified in the vicinity of holes. The holes will therefore grow undisturbed by each other until they run together. The resulting elongated hole will soon round itself off, and finally become circular.

B. In a combination of fresh paint on rubber, constituting an easily deformable plastic layer intimately connected with a strong plastic surface, holes appear as in a single plastic membrane. The paint flows freely aside without piling up. Both surfaces retain their

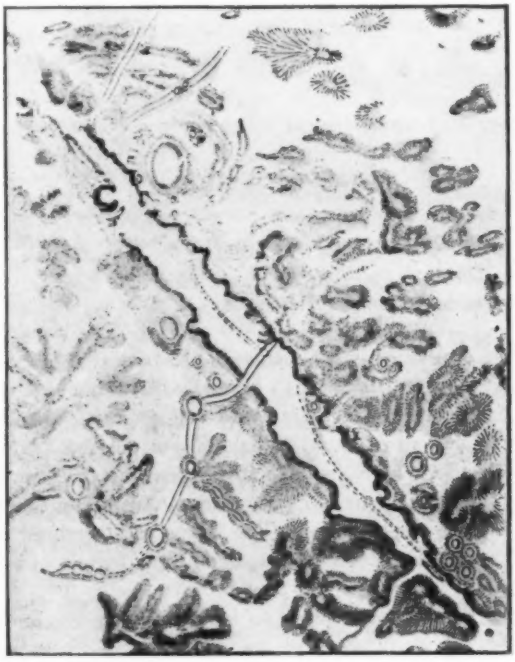

Fig. 2. The Great Valley in the Alps. The elastic property of the rock predominates.

original thicknesses and densities right up to the edges of the holes.

C. In two plastic membranes of about equal strength breaks appear as in the first two cases. Whether the membranes consist of fairly dry paint on rubber, or of two rubber membranes of different tensions sealed together by the heat of the adjustable lamp, walls of piled-up material are built around the edges. The membrane suffering the weaker tension acts as would a layer of partly congealed paint. The flow region is considerably narrower than it was before. Small hillocks or ridges may be formed around incipient craters.

D. In a faintly-elastic layer sealed to a plastic membrane (thick gold foil, heated rubber) the primary breaks are all narrow slits regardless of size. All along the slits are a number of small circular breaks in the plastic part of the membrane. As tensions increase, remaining radial in direction, the slits grow almost entirely by lengthening along their original directions.

A second experiment, on 'crater' formation in a mass rather than in a membrane, was performed as follows. A quantity of glue (hornleim) was saturated with half its weight of water and stirred

Fig. 3. "Ring mountain" formation in a solidified plastic mass.

for a considerable time at 90° to 95°C. until free from bubbles. On solidification this material undergoes a volume contraction of about 5%. This paste was carefully ladled out on a level glass plate, forming a layer of 3 mm. depth, the progressive solidification of which was studied by reflected and transmitted light from a frosted lamp. The processes 1 to 7 were completed in from 5 to 20 minutes:

1. Hundreds of small hemispherical breaks are formed. They grow steadily, but even the solid form shows many of the smallest.

2. Then follows a sinking of irregularly spaced circular regions, which grow elevated rims. The smaller formations develop faster than the larger ones.

3. In case of collisions between two unequal regions while both are still growing, the smaller is always further developed than the larger and encroaches upon it.

4. The smaller formations are on the average more regularly shaped than the larger. Their forms are sharper, and their ratio of depth to diameter is larger.

5. In the centres of large rings there will often develop small regular depressions.

6. There is a faint tendency for the tiniest depressions to avoid the inner surfaces of the larger structures.

7. There are sunken craters, deep craters, craters with convex bottoms, incomplete craters, and many low walls and ridges. In the interior of many rings are formed breaks which often develop into crater-rows.

Ridges form best with material of high density, and as the density increases, the surface takes on an increasingly chaotic appearance. Crater formation stops, but, owing to internal strains, the surface may still be modified. After some hours or days, depending upon temperature and humidity, the very surface layer is on the common boundary between a plastic and a brittle material. If now the surface is subjected to radial tensions, as by pressing the glass plate with a ring against a sphere, a pronounced change occurs in the albedo of well-developed 'ring mountains'. Their walls become bright or white, and long, brilliantly-white rays radiate in all directions from the mountain.

The Modern Tectonic Theory

We shall now describe the main assumptions and processes of Ingolf Ruud's theory. It is assumed that at one stage of its development the moon possessed an exceedingly hot liquid interior and a thin solid crust. Owing to the rapid cooling of the surface, but not of the interior, there was a period of surface contraction not matched by a corresponding volume contraction of the interior. It follows that

there would develop a system of strong primarily radial tensions at any point on the surface. Because of the small radius of the moon there would also develop a downward tension in addition to gravity all over its surface. (It is immaterial how these tensions came about, whether by volume contraction of the surface rock or by its metamorphic change to rock of greater density, or even by crystalization of the interior to rock of lower density. It is not necessary for the action of the theory that the interior was ever liquid.) It is assumed that the density of the rock increases with depth. The surface rock is assumed to be of low density, brittle and non-elastic. Thus it can not stretch or flow as the tensions approach its breaking limit. It can

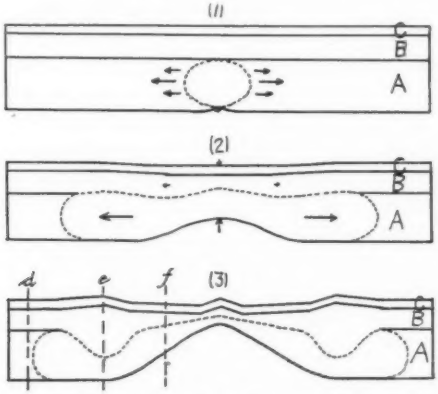

Fig. 4. Three stages of ring mountain formation.

only crumble or break into sections. Below this layer there is, just as on the earth, a heavier, stronger, elastic layer, perhaps similar to some of the heavier lavas. As the tensions slowly increase, this layer may stretch. If breaks form in it, they will preferably have the shape of long narrow slits. This layer may not be important enough to impress its characteristics upon the surface in general, but that it is widely present is evidenced by the thousands of crater-rows, thousands of rills, scores of slit-like breaks, and by the commonly observed elongated shape of many central peaks. Below these two layers lies the still heavier plastic layer. As the tensions in it increase, the rock can flow and change shape, but it is permanently deformed and does

not regain its shape, even if the tensions should disappear, as they will if perfect adjustment takes place. This layer will flow horizontally in all directions away from some accidentally-weakened centre, and any breaks formed in it will be circular. At still greater depths the rock gradually passes into the heavy liquid magma on which the crust rests. The magma, though of higher density than the rock, may nevertheless be forced upward into the plastic break, floating a piece of surface rock, or forcing up a convex floor covered with light-coloured rock. Or it may pierce the surface while still liquid, flooding the crater with a level dark-coloured floor, whose height may vary several thousand feet in neighbouring craters, as is observed by Shaler. The pressure responsible for the upward flow of material originates partly from the downward component of the radial tensions and partly from the weight of the ring wall.

The Ring Plains

The general progress of a plastic flow is illustrated in the accompanying diagram representing three stages during the ring wall formation. For the sake of simplicity the plastic, elastic, and brittle regions are shown as the distinct layers A, B, and C, but it should be noted that there is no definite boundary between these layers, as one shades gradually into the other. The same rock may by a change of temperature and pressure change from one classification to some other. But at some definite level one property may be said to be characteristic of the typical behaviour of rock at this and neighbouring levels. At (1) some region in the plastic layer surrounding an accidentally weakened point begins to flow horizontally, the velocity of the flow being indicated by the size of the arrow. At (2) layer A has become thinner, and the flow is well under way. As the layers B and C ride in firm contact with A, B, and possibly C, will partake in the flow to a small extent, decreasing towards the surface. A large batholith of heavier intrusive rock, possibly liquid, but not necessarily so, has gradually appeared under the floor of the incipient volcanoid. The central region will now begin to drop as isostatic adjustments are setting in. The solidification or crystallization of the rock may counteract this tendency and level or even bulge the floor, analogous to the process recently described by Willis in an article stressing recrystallization as an important cause of the formation of granite domes in the Japanese

islands. At the edge of the flow region conditions for orogenesis on a circular pattern will be present as the flow is restrained by the undisturbed solid crust further outside, and the layer B, and possibly C, will be squeezed together, forming a large accumulation of folded or crushed rock. At (3) the normal development is complete, with the layer C forming all or most of the visible part of the ring wall. The crushed, strained, or folded rock is lifted into a circular system of ridges. The curvature of the surface is neglected in the diagram, but may of itself modify the shape of the structure. Although the height of the central peak, if present, depends mainly on the tensions in the surface, the height of the ring wall depends to a large extent upon the isostatic adjustment. In general the height of the rim of the wall is 10 to 20 per cent. of the thickness of the compacted rock on which it rests. The width of the wall is a high multiple of its height. The thickness of the active layer is often greater than the radius of the ring. As a result of isostatic adjustment three columns of rock of equal cross-section down to the same depth (below layer A) have equal weights. If a section at (d) represents the general lunar crust, one at (e) must be longer because a larger portion of its length is of lower density, while one at (f) must be shorter because of the thinness of layer B at this place. As a result, (e) will float higher than the general surface, (f) lower.

For the smaller craters tensions are of greater importance than isostatic adjustments. Schroeter's Rule, that the volume of that part of any ring mountain excavated below the general level of the undisturbed lunar surface in its neighborhood, equals the volume of its wall, is substantiated by a complete mathematical formula involving both the effect of tensions and of isostasy. The numerous observed deviations from the rule can also be derived from the formula, which predicts that small craters, having generally incomplete isostatic adjustments, are relatively the deeper.

The Maria

As the density and thickness of a plastic shell increases, flows develop, if at all, on a larger scale, and proceed at a slower rate. While the lunar crust is still thin the small perfect structures of various diameters are formed. At a later date the processes of plastic flows proceed in the now deeper crust, and structures of larger diameters

are formed by new upheavals. The small, strong, older craters are preserved, or merely shoved about. The more recent formations, ring plains, walled plains, differ more from a stereotyped plan, and may be slightly elongated (spooned craters) along some line of maximum tension. Last in the series of crater formations are the processes forming the maria, slow plastic flows in nearly solid rock, perhaps only a few centimetres a century, under large portions of the surface. Mountain ranges are thus formed at the edge of the flow, being lifted by isostatic adjustments, which now act only on this larger scale. Lunar tectonic forces tending to break the floors are augmented by differential strains that may have developed due to the change in the earth-tide, with respect to which the solid lunar crust is no longer a level surface, as it was when the moon 'froze up.' The resultant movements may have developed enough heat by friction to produce large pockets of liquid lava. Extensive flows of very mobile material issue forth from one or more cracks produced when some large-scale catastrophic adjustment takes place somewhere along the now prevailingly circular fault lines. The tide of lava floods the interior of the circular embankments, or, where these are missing, spends itself forming the shores of those maria which have no distinct boundary. As the flooded region cools, small perfect craters are formed on the new floors, but their sizes have an upper limit due to the shallowness of the new flow region. On the borders of the maria tensions come and go, change directions and reverse, thus forming the chaotic creations observed in many places, where there is almost nothing but wrecks of craters. The mathematical formula for crater formation shows that there is a tendency towards the formation of structures with relatively smaller walls on the maria than on the highlands. The half-filled or tilted rings may be developments resulting from unsymmetrically distributed forces. Twisted ring plains, like Posidonius, may be the result of a gradual change in the directions of the forces.

The Lunar Rays

The high reflecting power of the highlands and rays is explained by a condition of strain in the material. The dark parts of the maria and the surface rock inside dark bottom craters is unstrained. A finely divided solid material will possess a light colour and a large

phase effect regardless of the colour of the undivided material. According to Schoenberg the light from the lunar rays forms 2 0per cent. of the total light of the full moon. They lose 30 per cent. in intensity when the phase angle is only 20°. This large albedo and phase effect both suggest that the rays are regions of crumbled, not merely metamorphosed or crystallized, rock. Of the various explanations of the rays Mädler wrote: "If everything else fails, we must assume that the rays are regions where the internal structure of the floor has experienced some change that greatly enhances its power to reflect light."

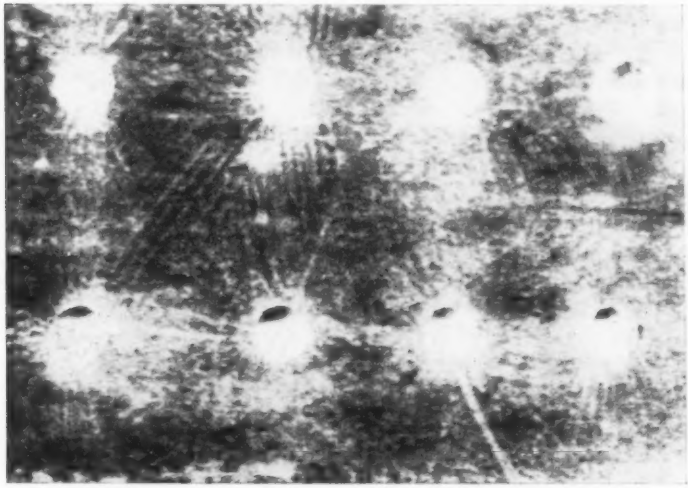

Fig. 5. Flow lines in a steel plate.

It may be computed from the already assumed constants of the rock, and the observed temperature changes of the surface, from about —100° to +100°C., that in any area not permitting the expansion to take place, strains will exist of about the size which the material can withstand without breaking. This effect will be disastrous in places where large tensions already exist either due to some residual strain from the plastic flows or from buckling of the solid upper rock layer. In the systems of Tycho rays there is a tendency for the members of each system to be tangent to craters of the same size as their crater

of origin. Experiments on flow lines between holes in solid steel plates also show a similar tendency. The evidence is present that the lunar rays are flow lines in the lunar crust formed after complete solidification. According to the Mohr-Guest theory of material breaks, flow lines will be radial when, as is the case in lunar craters, the tangential rim tension is of the same sign and exceeds the radial tension. When the temperature effect is superposed upon the already existing tensions about a flow centre, grinding may start along any line of maximum tension, and, once started, there will be a tendency towards cracking at the ends of the old groove. The rays will preferably start from a volcanoid because this is likely to be a spot surrounded by residual high tensions from causes other than heat expansion. However, rays do appear on isolated parts of the surface, which is not contrary to the theory. To-day the Mohr-Guest theory has been superseded by the Hubert-v.Mises-Hencky theory, according to which flowing proceeds along all three directions of maximum tension. It is of interest to examine to what extent this may be made to apply to the Copernicus rays, to stray elongated patches of light coloured surface at any angle to the radial rays, and to vertical flows of slight elevation. In connection with the latter, it has been suggested, that the best observations yet made may not exclude the possibility that the rays possess in places very slight gradual elevations, up to perhaps 25 feet.[6]

REFERENCES

[1]Shaler, N.S.: A Comparison of the Features of the Earth and the Moon. *Smithsonian Contributions*, vol. 34, 1903.

[2]Ruud, Ingolf: Ueber die Entwicklung der Ringgebirge. *Zeitschrift für Astrophysik*, vol. 8, p. 295, 1934.

[3]Marshall, Roy K.: The Origin of Lunar Craters. *Popular Astronomy*, vol. 51, p. 415, 1943.

[4]McMath, R. R., Petrie, R. M., Sawyer, H. E.: Relative Lunar Heights and Topography. *Publ. Obs. Univ. of Michigan*, vol. 6, p. 67, 1935.

[5]Nádai, A.: *Plasticity*, McGraw Hill, 1931.

[6]Munro: *Science*, vol. 81, p. 400, 1935.

University of Washington,
Seattle, Washington,
December 1, 1946.

ERECTING STAR DIAGONALS

By F. K. Dalton

IN the February 1947 issue of the Journal, the writer mentioned his application of the roof prism as a star diagonal for an astronomical telescope and suggested the advantages of such a device in giving the moon, eclipses, or other celestial objects, their proper orientation and, at the same time, retaining the convenience of the diagonal in viewing objects at high altitude in the sky.

When observing an object directly through an astronomical telescope, finder telescope or surveyor's transit, the image seen is usually inverted, as in a camera. By means of various further inverting devices, such as erector lenses, or the prism system in binoculars, the image can be re-inverted so as to appear erect. These devices all require the observer to look in the direction of the object being viewed and this often places him in a very inconvenient and cramped position when observing an object that is almost directly above him.

The usual star diagonal, with right-angle glass prism, undoubtedly was developed for the convenience and comfort of observers by using the reflecting feature to bring the rays out of the telescope at right angles to the optical axis of the instrument. Thus, in viewing an object near the zenith the observer looks in an approximately horizontal direction and, for objects in other parts of the sky, he looks downward from the horizontal, which usually is much more convenient and comfortable than placing one's eye below the telescope and looking upward through it. The ordinary star diagonal, however, has one disadvantage,—while it erects the image on one axis, i.e., the vertical, it does not reverse it on the other axis, i.e., the horizontal. Thus, the first quarter moon, though standing erect, will appear to bulge to the left rather than to the right, which frequently confuses the inexperienced spectator and leads to an inquiry as to why the moon has become turned around. With this condition he cannot readily compare the image he finds in the telescope with the moon as he ordinarily sees it.

The erecting star diagonals, figures 1 and 2, with which the writer has been experimenting, have Amici roof prisms that combine a fully erecting system with the convenience of the star diagonal and retain all of the advantages of both. There is still a further advan-

tage in that roof prisms can be used to turn the optical axis through an angle of 120°, figure 2, or slightly more, whereas the triangular glass prism is limited quite close to 90°. This greater angle adds appreciably to the convenience of the observer in viewing objects in

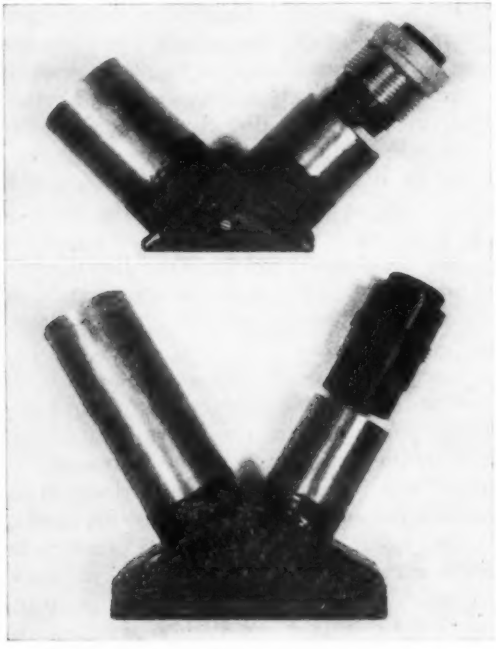

FIGURE 1 (*above*). Erecting Star Diagonal, with 90-degree Amici Roof Prism, and the Eyepiece of the Navy 6 × 30 Binocular. (The mounting is suitable also for a right-angle prism.)

FIGURE 2 (*below*). Erecting Star Diagonal, with 120-degree Amici Roof Prism, and the Eyepiece of the Navy 7 × 50 Binocular.

any part of the sky at altitudes higher than 30° above the horizon.

As the roof prism provides the erecting system, the spectator ees the moon, eclipses, etc., as he expects to see them; he is not onfused by total or lateral inversion, and promptly proceeds to dentify certain markings with which he is familiar. He is much

better satisfied than if the moon have some other orientation, and he enjoys the convenience of the diagonal feature.

The use of the erecting star diagonal introduces a problem in the matter of focussing range of the telescope, due to the path of light through the roof prism usually being longer than that through the ordinary right-angle prism. These erecting diagonals, therefore, must be placed nearer to the objective lens, or mirror, than is required with the usual star diagonal. The focussing range of the telescope may not be sufficient to take care of this or, it may be necessary, for proper focus, to have the diagonal so close to the finder or other fittings that they interfere with the observer in preventing him from conveniently placing his eye at the eyepiece.

All standard eyepieces of the writer's Clark refractor telescope are of the Huygens type,—negative eyepieces, having the primary focus of the objective lens within the eyepiece cell. A solution to the problem of focussing range, for low powers, appeared to be in the use of the Ramsden or Kellner positive eyepieces with the primary focus in front of the field lens. These would require that the diagonals be farther from the objective lens than when negative eyepieces were used. The writer, therefore, has obtained some positive eyepieces of low power,—the standard eyepieces of the 6 × 30 and 7 × 50 Navy binoculars, figures 1 and 2, and of the Type BI Elevation telescope,—and has found these highly satisfactory, not only in solving the problem of focussing range but in width and flatness of field, and in sharpness of detail as well. These eyepieces give this telescope a magnification range of 55x to 82x. In both of the binocular eyepieces, the spacing between lenses has been reduced, below specified spacings, in order to minimize the optical interference of any dust particles which may collect on the front surface of the field lens but the desired flatness of field in the eyepiece is still retained. These changes in spacing have been fully justified by the good results obtained.

For higher powers, 100x and above, using eyepieces of shorter focal length than for lower powers, there is not so much to be gained in focussing position by replacing negative eyepieces with the positive type in corresponding power and, for these higher magnifications, the focussing range of the writer's telescope is satisfactory with the negative eyepieces when the 90-degree roof prism, figure 1, is used. The optical path through the 120-degree roof prism, figure 2, however, is too long to permit its use in the

higher magnification range, with either positive or negative eyepieces, keeping within the convenient focussing range of this telescope for celestial bodies. For these reasons, the writer has found it unnecessary to construct positive eyepieces for the higher powers.

These Amici roof prisms are similar to the triangular glass prisms in the ordinary star diagonals except that the reflecting face, i.e., the hypotenuse in the right-angle prism, instead of being one flat surface consists of two flat faces at 90° to each other, resembling the double pitch roof of a building with a straight ridge. Each ray of light is reflected twice within the prism, the rays entering it on the left side being reflected over to the right side, and vice versa. This, with the vertical inversion as in the ordinary diagonal, gives the fully erect image in the telescope.

When the roof prism is used as a diagonal for a telescope, the ridge is not usually visible in the eyepiece. If, however, a positive eyepiece be of such very low power, i.e., very long focal length, that the ridge, or some part of it, is at or near the position of the image being magnified by the eyepiece, the ridge may then be visible, either sharply or as a ghost, and be superimposed on the image. If this condition occur, the trouble may be remedied by drawing the eyepiece away from the prism—but not by moving it closer—and then refocussing the telescope. The writer has found a ghost image of the ridge in a negative eyepiece of low power but this disappears when the positive eyepieces are used.

The application of roof prisms, as erecting star diagonals, to an astronomical telescope provides a new and useful type of attachment with definite advantages and there does not appear to be any reason that they could not be used more generally. The astronomer and surveyor, of course, are familiar with inverted images and the partial inversion of the right-angle prism, and so are not confused by these inversions, but there still is much to be said in favour of the fully erect image combined with the convenience of the diagonal, especially for the spectator.

Assisting the spectator is important, for he has demonstrated that he is deeply interested in the Heavens and all that he can see in them. To improve the instruments used in helping him to see and better to understand the celestial bodies is a worthwhile service which the Society is well prepared to render.

SIDEREAL AND SOLAR TIME

By H. Boyd Brydon

A COMMON, perhaps the chief stumbling block one meets when beginning the study of astronomy is the difference between sidereal time and solar or civil time, between a sidereal day and a civil day. The very simplicity of the difference makes its explanation the most difficult for the beginner to grasp.

The dictionary defines a day as "the time taken by the earth to make one complete turn on its axis." But how shall we mark when the turn begins and ends? If we mark it by the sun a day is the interval between successive crossings of the meridian by the sun. That is a solar day. If we use a star then a day is the interval between successive crossings of the meridian by that star. That is a sidereal day and observation shows that it is nearly 4 minutes shorter than a solar day; a good illustration of the necessity of understanding what we mean when we start to argue.

The result is that in a year there are, neglecting fractions, 366 sidereal days but only 365 solar days. What causes the difference?

It arises from a combination of circumstances. First: One complete rotation of the earth on its axis is completed each successive time any certain meridian, our own for instance, passes the vernal equinox point. This point is so immeasurably distant that as seen from it the earth's orbit may be considered merely as another point. The result is that straight lines drawn to the vernal equinox point from any and all parts in the orbit may be considered as though they were drawn from a single point.

Since there are 360 degrees in an orbit and, again neglecting fractions, 365 ordinary days in a calendar year, the earth moves round its orbit at an average rate of 360/365 or nearly 1 degree a day. It follows that the same meridian cannot face the sun again until the earth has rotated on its axis by just that much more than a complete turn which requires about 4 minutes longer.

Many more or less successful attempts to render this difference understood by a diagram or illustration by reference to familiar things have been presented. One of the latter which so far as the writer

is aware has not been published is based upon the use of an ordinary watch. Being a sort of working model of the two kinds of time it has the advantage that the student can experiment with it by himself.

First: release the hands of the watch from the clock-work by the hand-set knob so that they can be turned freely and set them at 12 o'clock. Next: imagine that the centre of the dial is the end of the earth's axis, the minute hand is a meridian and the direction from the centre to 12 o'clock points toward the vernal equinox. Clearly then when the hands are turned, every successive time the minute hand, our meridian, passes the 12 o'clock point it marks the completion of one complete turn: a sidereal day.

Now for a solar day. Imagine that the hour hand is the earth, the circle of the hours is its orbit and the centre of the dial is the sun. Then as the minute hand, our meridian, passes over the hour hand it is in line with the sun and represents the moment of noon by solar time. As the interval from one noon to the next is one solar day each passage of the minute hand over the hour hand marks the completion of a solar day. The additional distance past the 12 o'clock point that the minute hand must turn to reach successive positions of the hour hand represents the greater length of a solar day compared with a sidereal day. As the hour hand, the earth, travels round its orbit the total of these individual differences increases. We have now to show that in the whole orbit or a calendar year this total difference amounts to one day.

Beginning with the hands set at 12 o'clock continue to turn them, clockwise for convenience, until they both reach 12 o'clock again, noting, carefully, for the count becomes a little confusing toward the end of the circuit, the numbers of times the minute hand passes the 12 o'clock point and the hour hand respectively. It will be found that it has passed the 12 o'clock point 13 times and the hour hand, the earth, only 12 times, thus in the course of a complete revolution round the orbit or a calendar year, gaining one sidereal day over the number of civil or solar days.

In this working model 12 points round the orbit have been taken for the position of the hour hand, but the precise number is of no consequence. In passing round the orbit the difference is always

one. It arises, of course, because one of our reference points, the vernal equinox, is outside the orbit and the other, the sun, is within it.

We live by solar time or rather by standard time which is simply a convenient modification of it for business purposes. But the stars move by sidereal time and our watch experiment has shown that in the course of a year 0-hours by sidereal time, which is the same as 0-hours of right ascension, occurs at all hours of the day and night. Furthermore any certain star or constellation can be seen only when it is above the horizon at night-time.

On some star maps as for instance those available from the headquarters of this Society the date and solar time are given corresponding to the sidereal time when a constellation is on or near the meridian. Lacking such maps some way is needed of determining approximately the sidereal time corresponding to any certain day, hour and minute of civil time so that by comparing its right ascension therewith we may know whether the star can be seen at the time specified.

Fortunately there is a simple rule. It is based on the facts that at the vernal equinox, about March 21, 0-hours by sidereal time occurs at noon by local mean solar time, and that as a sidereal day is nearly four minutes shorter than a solar day, 0-hours by sidereal time occurs about four minutes earlier on each succeeding day. Here is the rule:

To obtain the approximate sidereal time corresponding to any specified day, hour and minute add together two hours for each complete month counting from the 22nd day of March to the last 22nd day before the specified date, four minutes for each complete day from noon on that 22nd day to noon on the specified day and the hours and minutes from that noon to the time specified. If the sum exceeds 24 hours deduct 24 hours from it; there are only 24 hours in a day. The result, within a few minutes depending principally on one's difference of longitude from the standard time meridian, will be the approximate sidereal time sought. For example:

Required the approximate sidereal time on Aug. 15, 9.00 p.m.

	h.	m.
Mar. 22—July 22: 4 mo. x 2	8	00
July 22—Aug. 15 noon: 24 d x 4	1	36
Noon to 9.00 p.m.	9	00
Approximate sidereal time required	18	36

The rule can be worked equally well backward to find the approximate civil time when a specified star will be on the meridian at say 9.00 p.m. For example:

When will Antares, R.A. 16h 26m, be on the meridian about 9.00 p.m. The problem is to find when one's sidereal time will be 16h 26m at 9.00 p.m.

Deduct 9 hours, leaving sidereal time at noon on the day required 7h 26m. Dividing by 2 gives 3 complete months from March 22 or June 22 and leaves 1h 26m. Dividing 1h 26m by 4 gives 18 days plus 2 minutes. Whence the approximate civil time when Antares will be on the meridian is July 13d 9h 02m p.m.

2390 Oak Bay Ave.
Victoria, B.C.

OUT OF OLD BOOKS

By Helen Sawyer Hogg

Derham's Catalogue of Nebulous Objects from Hevelius' Prodromus

SOMETIMES mentioned as the first catalogue of nebulae is the work by Dr. Derham, Canon of Windsor, in the Philosophical Transactions of the Royal Society for 1733, vol. 38, pp. 70-74. In this paper Derham printed a list of 16 nebulous objects he had gleaned from the star catalogue Prodromus Astronomiae by Hevelius, published posthumously in 1690. Derham's paper was translated into French and published by de Maupertuis in the Histoire de l'Academie royale des Sciences, Paris, 1734. Along with the list of 16 objects, Derham gives a quaint and interesting philosophical discussion of nebulae. The original work is rare, and the list of nebulae very inaccessible, since the Abstracts of the Philosophical Transactions do not reprint it, but merely summarize the ideas.

In order to appraise the scientific content of this paper, and identify the sixteen nebulous objects, I have borrowed the copy of the Philosophical Transactions from the University of Alberta. With the help of the positions obtained therein, and particularly with aid of work done by Bigourdan on early catalogues, published in the Paris Annals, Observations 1884, I can give the most probable identifications for these objects.

Obviously they have puzzled many astronomers since their publication, for there are few direct statements about them. Messier, especially, has commented on a number of them in the Connaissance des Temps for 1783, 1784, and 1787, on a page titled "Nébuleuses découvertes par différens Astronomes, que M. Messier a cherchées inutilement."

It is decidedly startling to discover that of the sixteen nebulous objects listed by Derham, only two are now contained in our modern catalogues of nebulae or star clusters. To a person who has been taught that Derham's was the first list of nebulae published as such, this comes as a real shock. Fourteen of the objects have no con-

nection with nebulous objects at the present time. They consist of two or three stars close together, or bright patches of the Milky Way. This is more easily understood if one recalls that Hevelius' catalogue from which Derham derived most of his material was the last star catalogue to be made without the help of a telescope.

Derham follows his catalogue with a brief mention of six other nebulous objects he has taken from the article by Halley, which was reprinted in the February issue of this JOURNAL. These are all bona fide nebulous objects, representing the most important members of their various classes to be found in the heavens.

The first fourteen objects listed by Derham are drawn from Hevelius. Actually there would seem to be some discrepancy between early copies of Hevelius' work, as Derham, Bigourdan, and I do not always agree on what Hevelius has listed as nebulous. Derham did not include the Praesepe Cluster in Cancer, a true star cluster; and another group, now known as 4 and 5 in Vulpecula, not a true nebulous group. Both of these are listed by Hevelius.

The last two of the sixteen objects listed by Derham are taken from Halley's Catalogus Stellarum Australium. Derham does not indicate this and I am indebted to Bigourdan for this information. One of these is a genuine nebulous object, now known as the star cluster Messier 7. The other is a portion of the Milky Way. Table I gives the identifications of the sixteen objects, with the numbers from the catalogue of Hevelius.

Therefore, of the 14 nebulous objects which Derham extracted from Hevelius' catalogue, only the first one, the Great Nebula in Andromeda, is a true nebulous object. It is almost ironical then, that Derham ended his catalogue with the comment: "But if any one is desirous to have a good View of these, or any other of the Nebulosae, it is absolutely necessary that he should make use of very good glasses, else all his Labour will be in vain, as I have found by Experience, and before noted." And Derham was basing his catalogue on a list made without "glasses"!

It is possible that Derham had considerable trouble trying to find these objects in the sky. Of Halley's objects mentioned at the end, Derham states specifically that he has seen all five visible in England. But nowhere does he state seeing any mentioned by Hevelius,—rather he says "my Reflecter loseth its Excellence and

Power, by beginning to be tarnished." It would nowadays appear that Derham's reflector was too good to turn these chance naked-eye groupings into nebulous objects!

As a catalogue of nebulous objects then, Derham's list must be considered a somewhat pathetic failure. But Derham correctly grasped the importance of nebulae and was exceedingly shrewd in picking the Andromeda nebula as the most important when he says

TABLE I

IDENTIFICATION OF OBJECTS IN DERHAM'S LIST

Hevelius	Derham	Present Identification
32	1	Great nebula in Andromeda, Messier 31.
380	2	σ Capricorni } Messier doubts that these nebulous
381	3	π Capricorni } objects exist.
382	4	o Capricorni } The stars π, ρ, o Cap form a sort of
383	5	ρ Capricorni } cluster.
618	6	ω_1, ω_2, ω_3 Cygni. } Messier doubts that these
619	7	Two stars of 6th mag., 1° apart; Milky Way. } nebulous objects exist.
794	8	Region of 88 Herculis where neither nebulosity nor a cluster is visible to unaided eye.
798	9	f Herculis.
804	10	32, 33, 34 Ophiuchi, near 60 Herculis. Messier could find no nebulous object here.
1113	11	34, 35, 37 Pegasi. Messier wondered if this object could be his No. 15 with position greatly in error.
1259	12	Brilliant part of Milky Way near s Scuti.
953	13	ξ_1 and ξ_2 Librae (13 and 15) with 17 and 18.
1496	14	74 and 75 Ursae Majoris.
Halley 20	15	Brilliant part of Milky Way NNE from ζ Scorpii.
Halley 29	16	Bright galactic cluster Messier 7, NGC 6475.

"some seem to be more large, and remarkable than others; but whether they are really so, or no, I confess I have not had an Opportunity to see, except that in *Andromeda's* Girdle, which is as considerable as any I have seen." The publication of Derham's paper served to open a door into one of the most important branches of astronomy which the development of the telescope has brought within our grasp.

III. *Observations of the Appearances among the Fix'd Stars, called Nebulous Stars. By* W. Derham., *D.D., Canon of Windsor, F.R.S.*

Having last Autumn made some good Observations, with my eight Foot Reflecting Telescope, of the Appearances in the Heavens, called *Nebulous Stars*, I think it proper to acquaint this Illustrious Society with them, to instigate others to make farther Observations of them, because I think there is much more in them worthy of the Inquiry of the Curious, than hath hitherto been imagined, and because I fear I shall not be able to pursue my Observations much farther, by reason my Reflecter loseth its Excellence and Power, by beginning to be tarnished.

But if any one would have a good View of these *Nebulosae*, it is of absolute Necessity that he makes use of very good Glasses, else all his labour will be Lost, as I found by Experience.

These Appearances in the Heavens, have born the Name of *Nebulous Stars*: But neither are they *Stars*, nor such Bodies as emit, or reflect Light, as the Sun, Moon, and Stars do; nor are they *Congeries*, or *Clusters* of Stars, as the *Milky-Way*: but whitish *Areae*, like a Collection of *Misty Vapours*: whence they have their Name.

There are many of them dispersed about, in diverse Parts of the Heavens. This Catalogue of them (which I transcribed from *Hevelius's Prodromus Astronomiae*) may be of good use to such as are minded to enquire into them.

Besides these Dr. *Halley*, in *Phil. Trans.* N° 347, hath mentioned one in *Orion*'s *Sword*; another in *Sagittary*; a third in the *Centaur* (never seen in *England*); a fourth preceding the right Foot of *Antinous*; a fifth in *Hercules*; and that in *Andromeda*'s *Girdle*.

Five of these six I have carefully viewed with my excellent eight Foot Reflecting Telescope, and find them to be Phaenomena much alike; all except that preceding the right Foot of *Antinous*, which is not a *Nebulose*, but a *Cluster* of *Stars*, somewhat like that which is in the *Milky-Way*.

Between the other four, I find no material Difference, only some are rounder, some of a more oval Form, without any Fix'd Stars in them to cause their Light; only that in *Orion*, hath some Stars in it, visible only with the Telescope, but by no Means sufficient to cause the Light of the *Nebulose* there. But by these Stars it was, that I first perceived the Distance of the *Nebulosae* to be greater than that of the *Fix'd Stars*, and put me upon enquiring into the rest of them. Every one of which I could very visibly, and plainly discern, to be at immense Distances beyond the Fix'd Stars near them, whether visible to the naked Eye, or Telescopick only; yea, they seemed to be as far beyond the Fix'd Stars, as any of those Stars are from the Earth.

And now from this Relation of what I have observed from very good, and frequent Views of the *Nebulosae*, I conclude them certainly not to be *Lucid Bodies*, that send their Light to us, as the Sun and Moon. Neither are they the *combined Light* of *Clusters* of Stars, like that of the *Milky-Way*: But I take them to be *vast Areae*, or *Regions of Light*, infallibly *beyond the Fix'd Stars, and devoid of them*. I say *Regions*, meaning Spaces of a vast Extent, large enough to appear of such a Size as they do to us, at so great a Distance as they are from us.

And since those Spaces are devoid of Stars, and even that in *Orion* itself, hath its Stars bearing a very small Proportion to its *Nebulose*, and they are visibly not the Cause of it, I leave it to the great Sagacity and Penetration of this Illustrious Society, to judge whether these *Nebulosae* are particular Spaces of Light; or rather, whether they may not, in all Probability, be Chasms, or Openings into an immense Region of Light, beyond the Fix'd Stars. Because I find in this

A CATALOGUE of the *Nebulosae*, extracted from *Hevelius*.

The Places of the *Nebulosae*	Their R. Ascent. *A.* 1660	Their Declinat. *A.D.* 1660
	gr. ′ ″	gr. ′ ″
In *Andromeda's* Girdle,	6 4 45	39 27 57 N.
In Forehead of *Capricorn*,	300 2 53	20 1 53 S.
Another preceding the Eye of *Capricorn*,	301 59 55	19 11 30 S.
Another following it,	302 35 9	19 36 0 S.
One above those, adjoining to the Eye of *Capricorn*,	302 25 31	18 48 58 S.
Preceding above the *Swan's* Tail, and last in its N. Foot,	304 54 8	47 54 20 N.
One following a Star above the *Swan's* Tail, out of the Constellation,	312 10 5	53 05 20 N.
On the outside of *Hercules's* left Foot,	264 52 46	48 9 10 N.
In the left Leg of *Hercules*,	265 38 37	38 5 50 N.
On the Top of *Hercules's* Head,	252 24 3	13 18 37 N.
At the Ear of *Pegasus*,	332 38 45	3 3 12 N.
In the Western Border of *Sobieski's* Shield,	272 32 34	14 23 35 S.
Under the Beam of the Scales of *Libra*,	219 26 15	9 16 27 S.
Above the Back of *Ursa major*,	183 32 41	60 20 33 N.
In the third Joint of *Scorpio*'s Tail,	12 43 00 ♐ Long.	19 1 0 S. Lat.
Between *Scorpio*'s Tail, and the Bow of *Sagittarius*,	24 32 00 ♐ Long.	11 25 0 S. Lat.

Opinion most of the Learned in all Ages (both Philosophers, and I may add Divines too) thus far concurred, that there was a *Region beyond the Stars*. Those that imagined there were *Crystalline*, or *Solid Orbs*, thought a *Coelum Empyraeum* was beyond them and the *Primum Mobile*: and they, that maintained there were no such Orbs, but that the Heavenly Bodies floated in the Aether, imagined that the Starry Region was not the Bounds of the Universe, but that there was a Region beyond that, which they called the *Third Region*, and *Third Heaven*.

To conclude these Remarks, it may be of use to take Notice, that in *Hevelius*'s *Nebulosae*, some seem to be more large, and remarkable than others; but whether they are really so, or no, I confess I have not had an Opportunity to see, except that in *Andromeda*'s Girdle, which is as considerable as any I have seen. In his Maps of the Constellations, the most remarkable are the three near the Eye of *Capricorn*; that in *Hercules*'s *Foot*; that in the third Joint of *Scorpio*'s *Tail*; and that between *Scorpio*'s *Tail* and the *Bow of Sagittary*. But if any one is desirous to have a good View of these, or any other of the *Nebulosae*, it is absolutely necessary that he should make use of very good Glasses, else all his Labour will be in vain, as I have found by Experience, and before noted.

REVIEW OF PUBLICATIONS

Making Your Own Telescope, by Allyn J. Thompson. Pp. 211 + xi, $5\frac{1}{2} \times 8\frac{1}{2}$ inches. Sky Publishing Corporation, Cambridge 38, Mass., 1947. Price $3.50.

This should prove a thoroughly useful book for anyone who wishes to commence the hobby of amateur telescope making. With this guide one should be able to make a first class reflecting telescope with a minimum outlay of money and time, and to commit a minimum of errors.

The book reflects the author's great experience in conducting classes of telescope makers in the Optical Division of the Amatuer Astronomer's Association, in the workroom at the Hayden Planetarium. The most direct and carefully tested steps are used throughout. The analysis of the grinding and polishing processes and results are discussed in detail, in a way that can be followed by hobbyists working alone or in groups.

The basic instrument discussed is a six-inch reflector, Newtonian arrangement, of four-foot focal length. This size gives a very effective telescope, without being too large and laborious for the beginner to construct without help. For such a telescope all the necessary materials are listed in detail. The mountings described are made of standard pipe fittings, which are also listed and fully diagrammed.

The total estimated cost of all materials for a six-inch telescope and rugged mounting is about thirty dollars.

The book is based on a series of articles which have appeared in the *Sky and Telescope*. These articles have been revised and unified into a very convenient handbook. Aided by this book, thousands of new amateur telescope makers will be added to the many thousand who in the past twenty years have taken up this fascinating hobby.

F. S. H.

Nuestro Maravilloso Universo, by C. Augustus Chant. Pp. 404, $5 \times 7\frac{1}{2}$ ins. J. Morata, Madrid, 1946.

Under the original English title, "Our Wonderful Universe," this introduction to astronomy is undoubtedly familiar to most readers of this JOURNAL. Since its first edition in 1928, and its careful revision and amplification in 1940, Professor Chant's book has enjoyed widespread popularity. The present Spanish edition was translated by Rafael Carrasco, with an introduction written by Enrique Gastardi.

Professor Chant's long and highly successful experience as a teacher of physics and astronony is demonstrated in the simple and interesting presentation of the subject matter. This, together with a generous use of excellent diagrams and photographs, accounts for the popularity of this book as an introduction to astronomy. The Spanish edition was preceded many years ago by editions in German, Polish, and Czechslovakian. In addition a French translation is now being published in Quebec.

F. S. H.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

History of "Notes and Queries"

The first time the heading at the top of this page was used in this Journal was in the issue for March-April, 1909, which was Number 2 of Volume III. However the title "Notes and Queries" had been a regular item in the programme of the meetings of the Society for many years. The present writer remembers that in the early 'nineties an Order of Proceedings to be followed at an ordinary meeting of the Society had been drawn up and, being approved, had been engrossed on a sheet of heavy paper, and was used by the chairman in conducting the meeting. Often after the main paper, or address, there would be a discussion, and questions would frequently be asked which did not refer to the subject in hand. So it was suggested that an additional division, to be named "Notes and Queries," be added to the formal programme. This was written in between two lines on the engrossed sheet.

But, as is well known, a publication bearing the name *Notes and Queries* had been in existence for many years. Indeed it made its first appearance on November 3, 1849, under the editorship of William John Thoms (1803-85). For almost a century it has served as a forum and information bureau for scholars, professional and amateur, and has had its ups and downs during that long period. Recently its publication was undertaken by the Oxford University Press, and in the July 1946 issue of *The Periodical,* which is published four or five times a year by that famous institution, there appears a historical account written by the present editor of *Notes and Queries.* From this the following extracts are taken:

> . . . . . the final impulsion to *N. & Q.* came from Thoms's interest in folk-lore (the word was his own coinage). The articles and correspondence on folk-lore which he had set going in the *Athenaeum* of 1846 had by 1849 become so extensive that no longer was there room for them in that paper. So at last *Notes and Queries* was determined upon, but the name only after long cogitation, much discussion, and some forcible opposition. One friend withdrew his offer of financial and other assistance, convinced that that title would be fatal!
>
> * * * * * *
>
> From the beginning *N. & Q.* has been bound up in half-yearly volumes, and has been grouped into Series of twelve volumes each. Each volume is fully

indexed, and an Index-volume to each series up to June 1935 (completing the Fourteenth Series) has been issued. The Index to the Fifteenth Series has been delayed by the war.

* * * * * *

For the first fourteen years of its existence *N. & Q.* was published by George Bell, but by midsummer 1863 his business had grown so large that he could not afford the space and attention for *N. & Q.* and for the next nine years it was published from its own office by William Greig Smith. When, in September 1872, W. J. Thoms resigned the editorship, Sir Charles Dilke acquired the paper, which then for forty-seven years (till the end of 1919) was published by John Francis and his family (and printed by them for nearly fifty years, from October 1872 to April 1921). It suffered financially in the war of 1914-18, and towards the end of 1919 Lord Northcliffe, (like Sir Charles Dilke before him, a hereditary enthusiast for the paper) came to its rescue. Until his death in 1922 the paper was published by *The Times*; and after that, for seven years, by the Bucks Free Press, who have printed it ever since. From December 1929 to March 1939 it was published by the Guardian and Church Quarterly Review Ltd., from whom it was taken over by the Oxford University Press. After 1914 the continuance and the special character of *N. & Q.* had been bound up with the uncertain fortunes of journalism. As far as it humanly can be, the paper is now assured of permanence.

C. A. C.

Note regarding John Couch Adams

Last year the hundredth anniversary of the dramatic discovery of the planet Neptune was celebrated (see last issue, page 190). The most notable feature of it was perhaps the statement prepared by W. M. Smart who is the first appointee to the position of John Couch Adams Professor of Astronomy in Cambridge University, England, and who has access to all the documents left by Adams when he died in 1892. New light is thrown on some of the details of the famous and bitter controversy of a hundred years ago, but it does not materially change our views on the relative merits of Adams and LeVerrier, although the dignified and unselfish bearing of Adams throughout his life has increased our admiration for him.

In the earlier years of the present writer at the University of Toronto there was a person on its staff bearing the title Yeoman Bedel. He was a higher-up servant whose chief duties were to assist in the conduct of the examinations and in the presentation of degrees. Around 1900 the one holding this position was named Spencer, a middle-aged man with considerable dignity and some education, who had been at Cambridge University and seemed to have information

about many things at that institution. Just how he came to Toronto the present writer does not know, but like some other persons who were assisted on their way from the old world to the new, he had some weak spots in his character although on the whole he was quite reputable and presentable. He seemed well acquainted with the life Adams led at Cambridge, and he stated that while the great mathematician was modest and retiring he had a pleasant musical voice with which he was not backward in entertaining his friends on some social occasions, and his favourite song was "Rosalie, my prairie flower."

It is pleasant to think of this great man who was able to attack successfully the most intricate problems in celestial mechanics and bring them to a numerical solution and yet who enjoyed a simple sentimental song like most of the rest of us.

C. A. C.

IN TIME AND ETERNITY

Ah, does the lake in winter cold
Grieve for the swan who sailed his breast
And on his forehead built her nest
In summer days of green and gold?

And does the tree sigh for the bird
Who couched within his leafy heart
And sang her blessing, to depart
In winter, and was no more heard?

Then if these weep for what they had
Much more do I now you are gone
Who in my house a summer shone,
By sweetness shod, by laughter clad.

The lake has faithful hope to see
His swan come back when days grow long,
The bird may sing again her song
From the green bosom of the tree,

But you no more will me delight;
A memory only, a dear ghost,
Taunting will tell me what I lost—
Pale star for my perpetual night.

—From *The House in the Forest and other poems*, by Averil Morley. Oxford University Press.

MEETINGS OF THE SOCIETY

AT TORONTO

October 22, 1946.—The Society met at 8:00 p.m. in the McLennan Physics Laboratory of the University of Toronto, Mr. Barker presiding.

The following 19 persons were elected to membership in the Society:

Mr. Earle F. W. Baker, 1904 Davenport Road, Toronto.
Mrs. A. V. Gallagher, 1173 Bay Street, Toronto.
Mr. A. B. Gray, 23 Willcocks Street, Toronto.
Mr. William A. Hamilton, R.R. 2, Weston.
Dr. William S. Keith, 55 St. Leonard's Cres., Toronto.
Mr. Jeffrey B. Kelly, 62 Bessborough Drive, Leaside.
Miss Helen McCaul, 492 Huron Street, Toronto.
Mr. Ronald C. Nicholson, 49 Garden Avenue, Toronto.
Mr. William C. Nixon, 7 Elora Road, Toronto.
Mr. Paul A. McClelland, 62 Bessborough Drive, Leaside.
Miss Marion Price, 97 Avenue Road, Toronto.
Mr. David Alex Mitchell, 40 Madison Avenue, Toronto.
Mr. Ernest E. Rose, 146 Dunn Avenue, Toronto.
Mrs. Lillian Foster Sears, 64 Roxborough St. West, Toronto.
Mrs. Irene Stringer, John English School, Mimico.
Mr. William T. Sharp, 73 St. George Street, Toronto.
Mr. W. Wilkins, 446 Roxton Road, Toronto.
Mr. Randall J. Zwinge, 27 Rumsey Road, Leaside.
Dr. Ralph E. Williamson, David Dunlap Observatory, Richmond Hill.

Dr. J. F. Heard presented a report on the Giacobinid meteors. He said the peak of the display was missed in the Toronto area because of clouds, although some of the brighter meteors were seen through the haze. It was generally agreed the peak was about 11.30 p.m. E.S.T. on October 9—about one hour later than predicted—when the sky in this area was almost totally overcast. Dr. P. M. Millman of the Dominion Observatory, Ottawa, observing at North Bay, apparently had better luck. In British Columbia, one amateur observer reported an average of 60 trails a minute over a half-hour period.

Dr. H. R. Kingston of the University of Western Ontario, London, gave a demonstration of some of the devices designed and constructed at the Hume Cronyn Memorial Observatory of U.W.O., for explaining celestial phenomena. These devices included the Sotellunium—designed to illustrate eclipse, seasons, phases and nodes of the moon, etc.—and a planisphere star map designed to indicate the rising and setting of celestial bodies in the proper perspective.

Mr. A. R. Clute, K.C., Vice-President, thanked Dr. Kingston for his interesting address and demonstration. The meeting was then adjourned.

November 5, 1946.—The Society met in the McLennan Laboratory at 8.00 p.m., Mr. Barker presiding.

Seven persons were elected to membership in the Society, viz:

Dr. H. D. Bett, 2559 Bloor Street West, Toronto.

Mrs. A. R. Clute, 5 Admiral Road, Toronto.

Mr. James G. Lee, 111 East Lynn Avenue, Toronto.

Mr. George E. Mack, School of Hygiene, University of Toronto.

Mr. James A. B. Milne, 386 Crawford St., Stamford Centre.

Miss D. G. Tock, 47 Jackman Avenue, Toronto.

Mr. Walter Rubidge, Canadian Kodak Co., Mount Dennis.

Dr. Ralph E. Williamson of the David Dunlap Observatory presented a memorial paper in appreciation of the life and work of Sir James Hopwood Jeans, who died on September 16. (A complete account is published in THE JOURNAL.)

Messrs. Raymond Pearce and Gerald Longworth then spoke on "Telescopes and Telescoptics—It's Fun to Make Your Own." Mr. Pearce pointed out that with shorter working hours, many people sought a hobby to help occupy their leisure time—and that they find the greatest entertainment not in being amused, but in creating something. To the telescope hobbyist there was a challenge in trying to make the best of the materials at hand. He warned that once the telescope-making bug gets hold of you, it just won't let go. He described some of the materials needed by the amateur telescope maker and the methods to be employed in constructing a useful instrument. Mr. Longworth described how a small inexpensive refractor could be made from war-surplus lenses and other optical parts at present available at reasonable cost.

After a period of open discussion, the meeting was adjourned.

November 19, 1946.—The Society met in the McLennan Laboratory at 8.00 p.m., Mr. Barker presiding.

Three persons were elected to membership in the Society, viz:

Mr. Archibald Maxwell Brown, c/o C. A. Parsons of Canada, Toronto.

Mr. Cyril R. Cole, Listowel.

Mr. T. Nicol le Seelleur, 16 Hopedale Avenue, Toronto.

Dr. Frank S. Hogg spoke briefly on the partial eclipse of the sun to be visible in Toronto on Nov. 23 as a 54 per cent. eclipse.

Mr. John A. Marsh, M.B.E., Ontario Commissioner of the Canadian Red Cross Society, and a Past President of Hamilton Centre, R.A.S.C., presented an illustrated address on "Exploring Space—An Amateur Looks at the Heavens." Describing astronomy as a very wonderful hobby, Mr. Marsh proceeded by the use of many lantern slides and his own enthusiasm to prove this to the uninitiated. We think of our earth as a pretty big place, but as we study the heavens we soon lose any ideas we ever had of the bigness of our planet. Our sun seems to us a giant, glowing orb, a pulsating, colorful star, but we don't have to go very far off into space to see that there is nothing very unusual about the sun. He took the audience on an imaginary trip past the planets of the solar system,

skimming by comets and out through the stellar fields beyond star clusters and nebulae, to the outer galaxies, 'the other universes beyond the Milky Way.'

On behalf of the members and guests, Mr. J. R. Collins expressed to Mr. Marsh the appreciation of the audience. The meeting was then adjourned.

AT LONDON

October 11, 1946—The members were fortunate in having as speaker the President of the Royal Astronomical Society of Canada, Dr. A. E. Johns of Hamilton, Ontario. Dr. Johns was welcomed by the president of the London Centre, Dr. R. H. Cole.

Subject of the evening was "Atomic Energy", the speaker stating that the 18th and 19th century scientific laws of conservation of mass and conservation of energy had been superseded by the law of conservation of energy *or* matter as these were manifestations of the same thing. Einstein and Hahn, two German scientists had been instrumental in giving the world a new concept of nuclear physics.

There were three fundamental bricks of which the universe was composed, Dr. Johns continued, protons, electrons and neutrons. By means of blackboard illustrations he demonstrated the principles of atomic number and atomic weight, showing the make-up from the lightest atom hydrogen to the heaviest and recently discovered neptunium and plutonium.

Transmutation was always going on in nature, he said, suggesting that the energy generated by the sun was due to the change from hydrogen to helium. The potential energy contained in two pounds of matter would be sufficient to produce all the electricity used in the United States during two months of the year 1939.

Commenting on the discovery of the atomic bomb, the speaker said the first chain reaction had been achieved in Chicago on December 2, 1942. Research work since then, most of it secret, had resulted in the production of the atomic bomb and the subsequent bombing of Japan.

Dr. Johns then gave a brief account of his recent trip to the Canadian atomic research laboratories situated at Chalk River, Ontario. Several slides were then shown which further illustrated many of the points previously dealt with by the speaker.

A social hour presided over by Mrs. Cole and Mrs. Emsley followed, during which the members were able to meet Dr. Johns.

November 8, 1946—The meeting was held in the Cronyn Observatory.

The opening topic of the evening, Canis Major, was ably dealt with by Dr. A. J. Watt. He defined the constellation's position in the sky and specifically mentioned the best known and brightest star Sirius together with its dwarf companion star.

Dr. Magee's talk on "Yardsticks of the Universe" was very informative and showed the great affinity between the two sciences Astronomy and Mathematics. He described the various astronomical units of distance stating

that distances in our own solar system were measured in light years and parsecs. By the method of triangulation supplemented by blackboard geometric diagrams the speaker demonstrated the means of measuring distances. The one-hundred inch mirror at Mount Wilson could discern extra-galactic nebulae 500 million light years away, he said, and the two-hundred-inch at Mount Palomar when ready for use would greatly extend the vision of astronomers.

The Ptolemaic system of a geocentric universe was supported by Aristotle, but the final discovery and measuring of star parallax was made on star 61 Cygni several decades ago, and officially discounted the former theory, and was final proof of the heliocentric system as outlined by Copernicus and Galileo.

The parallaxes of 3700 stars had been measured, Dr. Magee said, but many factors had to be taken into consideration as it took two to three years of observing together with the photographic results of forty of fifty plates. The triangulation method of determining stellar parallax was good for stars up to 150 light-years distant to obtain any degree of accuracy. Dr. Magee verified many of his measurements with a large scale slide rule in which many of the members were interested.

Mr. Colgrove displayed, at the close of the meeting, a map of the constellations which showed the relative positions of over nine hundred stars.

A. EMSLEY, *Secretary.*

AT MONTREAL

May 9, 1946—As has now become the custom for the last indoor meeting of the season, the meeting held on May 9, 1946, was an informal social with a variety programme. Three short papers were presented. The first, by Mr. A. R. MacLennan, Treasurer of the Montreal Centre, was a brief history of the calendar. In conclusion, he spoke of the need for calendar reform and of the advantages of the proposed World Calendar. This was followed by a resolution, carried unanimously, endorsing calendar reform in general and the World Calendar in particular.

DeLisle Garneau, Director of Observations, then gave a talk on "Summer Observations". He touched on the various fields of observation open to amateurs, urging the members to become active observers and stressing the genuine pleasure that they would derive from an increasing knowledge of the stars and constellations.

The third speaker of the evening was Dr. D. E. Douglas who gave a short paper on "The Solar System". Unknown to the audience, this paper contained numerous intentional errors. It was interesting to watch the reaction of the members as the talk progressed. The first couple of errors were regarded as slips of the tongue. Then the audience began to feel somewhat embarrassed for the speaker. Finally, it "caught on". When, at the

conclusion of the talk, the Chairman called upon the listeners to correct the speaker, numerous hands were raised. When the final count was made, it was found that only one of the eighteen errors contained in the paper had eluded the audience.

Mrs. E. Dawes and her Refreshment Committee then took charge of the meeting. As usual there was plenty of coffee, with cookies and cakes to spare, and the members enjoyed a social half-hour with friendly discussion before the meeting adjourned.

October 17, 1946—Annual Meeting—Henry F. Hall gave the President's address, choosing as his subject "Astronomy and English Literature."

In his introduction, Dean Hall stated that the purpose of the paper was to present some aspects of the influence of astronomical knowledge on the literary masterpieces in the English language. He deliberately omitted reference to works dealing directly with astronomical science since it was a study, not of the literature of astronomy, but of the effect of astronomy on general literature.

Dividing this influence into three phases, or levels, the Dean first spoke of the multitude of literary references to heavenly bodies that are quite incidental, treating the astronomical bodies as things of beauty or wonder and not involving any astronomical knowledge. It is natural, he said, that great writers of all languages, both of poetry and prose, should turn to such objects for inspiration, for the very beauty and constancy of the sun, the moon and the stars place them in a class by themselves in human experience.

The second phase of the study included those literary references which demand some knowledge or appreciation of the nature of the heavenly bodies themselves. Here, also, we have a great wealth of material. We find that many of the great English writers, such as Chaucer and Shakespeare, had considerable, if amateur, knowledge of whatever astronomical science existed in their day. The poems of Chaucer contain many references to celestial objects and movements. Naturally, considering the time in which he lived, many of these references have an astrological flavour but his descriptions, gathered together, give a picture of the Universe as conceived by Ptolemy. Shakespeare, too, it would seem, held a definitely Ptolemaic concept of the universe, but we note with interest from a passage in Act 1, Scene 2, of "King Lear" that he apparently scorned astrology.

The third, and perhaps to us, the most interesting level includes those literary works which refer to the development of the science of astronomy itself. For example, John Donne, who has been described as the greatest of the metaphysical poets, was familiar with the science of his day. He knew of Tycho Brahe's astronomical theories and those of Copernicus. He also mentions Kepler and Galileo and refers to the principle of the moving earth. The speaker also referred to the works of Bacon, Milton, Jonathan Swift, Shelley and others. Throughout his address he quoted many passages of

poetry and prose to illustrate the various points he raised. He closed by reading the inspiring prologue to "The Torch Bearers" by Alfred Noyes.

November 21, 1946—The members listened with intense interest to "The Story of the Flying Bomb" as told by Dr. John Stanley of McGill University who during the war years was a member of the Operational Research Centre, located in the Air Ministry, Whitehall. To use Dr. Stanley's own words, it was the story of "the most fantastic attack ever launched against a great city. Never before has such a peculiar weapon been used. Never has the defender known so long beforehand of the impending attack and been able to make such colossal efforts to offset it."

The work of the Operational Research Centre was largely mathematical, dealing with theoretical considerations affecting weapons, tactics and the like. Intelligence having reported that some form of long-range bombardment weapon was under development, intensive photo-reconnaissance was carried out to locate the launching sites. Intricate calculations and studies were then commenced to determine the most suitable method of attacking these sites. Dr. Stanley explained the many factors that had to be considered. The raids that followed definitely retarded the enemy's programme by many months. All this work, it must be remembered, was interwoven in the greater pattern of D-Day preparation.

Dr. Stanley gave an eye-witness account of the first V-1 attacks on London. The horror of the attacks was accentuated by the fact that the people "did not know what this thing was". They had not yet been told and found it all very un-nerving. He then gave a description of the bomb, its appearance and capabilities. It appeared as a small black, streamlined monoplane, about 20 feet long with a 16 foot wingspread. It was propelled by a peculiar type of jet-like engine called an athodyde, mounted above the tail, which gave off a series of explosions at the rate of 45 per second. The bomb usually flew at a height of from 1000 to 4000 feet, at a speed of between 375 and 400 miles per hour. He also described the device used for launching the bomb and the means by which it was steered and controlled.

In conclusion, Dr. Stanley paid tribute to the people he had been associated with in England. "If ever again in my lifetime," he said, "tragedy and disaster stalk the earth, may I take my share of it in the company of English men and women, for there are no finer people anywhere."

ISABEL K. WILLIAMSON, *Recording Secretary.*

The Royal Astronomical Society of Canada

OFFICERS FOR 1947

Honorary President—THE HONOURABLE GEORGE A. DREW, Prime Minister and Minister of Education for the Province of Ontario.
President—J. W. CAMPBELL, PH.D., Edmonton, Alta.
First Vice-President—ANDREW THOMSON, M.A., Toronto.
Second Vice-President—C. S. BEALS, PH.D., Ottawa, Ont.
General Secretary—E. J. A. KENNEDY, 3 Willcocks St., Toronto.
General Treasurer—J. H. HORNING, M.A., Toronto.
Recorder—H. W. BARKER, Toronto.
Librarian—D. W. BEST, D.D., Toronto.
General Council—ALBERIC BOIVIN, B.Sc., Quebec, P.Q.; S. C. BROWN, Toronto; A. J. COOK, Edmonton, Alta.; G. HARPER HALL, Montreal, P.Q.; HELEN S. HOGG, PH.D., Toronto; H. R. KINGSTON, PH.D., London, Ont.; L. T. S. NORRIS-ELYE, Winnipeg, Man.; ROBERT PETERS, Victoria, B.C.; LORNE R. ROGERS, B.A., Windsor, Ont.; H. D. SMITH, PH.D., Vancouver, B.C.; W. D. STEWART, B.A., Hamilton, Ont.; M. M. THOMSON, B.A., Ottawa, Ont.; and past presidents A. VIBERT DOUGLAS, M.B.E., PH.D., and A. E. JOHNS, PH.D.; also the presiding officer of each centre.

TORONTO CENTRE

Honorary President—C. A. CHANT, PH.D.
President—J. F. HEARD, PH.D.
First Vice-President—A. R. CLUTE, K.C.
Second Vice-President—FRANK S. HOGG, PH.D.
Secretary—FREDERIC L. TROYER
Treasurer—T. H. MASON
Recorder—J. R. TUCK, D. Educ.
Council—H. G. DUNCALFE, J. H. HORNING, MISS EVA SMITH, C. A. CROOK, HELEN S. HOGG, PH.D., W. R. SHERRICK, F. K. DALTON, B.A.Sc., E.E., RAYMOND PEARCE, R. E. WILLIAMSON, PH.D.; and past presidents E. J. A. KENNEDY, J. R. COLLINS, S. C. BROWN, D. W. BEST, D.D.; MISS R. J. NORTHCOTT, M.A.; and H. W. BARKER.

OTTAWA CENTRE

Honorary President—HOYES LLOYD, M.A.
President—M. M. THOMSON, B.A.
First Vice-President—P. M. MILLMAN, PH.D.
Second Vice-President—M. J. S. INNES, M.A.
Secretary—MISS C. B. HICKS, B.A.
Treasurer—STANLEY MOTT
Council—W. S. MCCLENAHAN, B.A., R. J. MCDIARMID, PH.D., R. G. MADILL, B.A., R. M. STEWART, M.A., A. H. MILLER, M.A.; and past presidents MISS M. S. BURLAND, B.A., T. L. TANTON, PH.D., and F. W. MATLEY.

HAMILTON CENTRE

Honorary President—W. T. GODDARD
President—REV. E. F. MAUNSELL, M.A.
Vice-President—T. M. NORTON
Secretary-Treasurer—G. MURCHIE
Curator—G. E. CAMPBELL
Council—W. FINDLAY, PH.D., A. E. JOHNS, PH.D., J. R. GRAHAM, F. SCHNEIDER, W. S. MALLORY, M.A., S. SISMAN, W. D. STEWART, B.A., H. B. FOX, D. G. BURNS, W. J. MCCALLION, L. O. JONES, O. PATON.

WINNIPEG CENTRE

Honorary President—DR. L. A. H. WARREN
President—D. R. P. COATS
Vice-President—R. A. STORCH
Secretary—MISS BEVERLEY SHARMAN
Treasurer—MISS MARGARET E. WATTERSON
Press Secretary—C. G. CARD
Council—MISS OLIVE ARMSTRONG, MRS. J. NORRIS, L. T. S. NORRIS-ELYE, V. C. JONES, L. W. KOSER and H. E. RITER.

MONTREAL CENTRE

Honorary President—MGR. C. P. CHOQUETTE
President—HENRY F. HALL
First Vice-President—F. DE KINDER
Second Vice-President—DR. W. BRUCE ROSS
Secretary—J. W. DUFFIE
Treasurer—A. R. MACLENNAN
Recording Secretary—MISS I. K. WILLIAMSON
Director of Observations—DELISLE GARNEAU
Librarian—C. M. GOOD
Council—A. M. DONNELLY, DR. D. E. DOUGLAS, ROSS FORD, G. HARPER HALL, F. W. HENSHAW, ARTHUR KNEELAND, F. P. MORGAN, W. H. C. MORTON, E. RUSSELL PATERSON, DR. A. NORMAN SHAW and past president D. P. GILLMOR, K.C.

VICTORIA CENTRE

Honorary President—R. M. PETRIE, PH.D.
President—ANDREW MCKELLAR, PH.D.
First Vice-President—W. R. HOBDAY
Second Vice-President—J. S. STEVENSON, PH.D.
Secretary-Treasurer—MISS J. K. MCDONALD
Recorder—G. L. DARIMONT
Director of Telescopes—R. PETERS
Librarian—MISS Y. LANGWORTHY
Council—ROBT. S. EVANS, MRS. J. R. NOBLE, E. H. POPE, H. A. REID, M. TRUEMAN, MRS. C. S. YARWOOD.

LONDON CENTRE

Honorary President—H. R. KINGSTON, PH.D.
President—DR. A. J. WATT
Vice-President—O. KILBURN
Secretary-Treasurer—ALBERT EMSLEY
Council—DR. G. CALDER, MRS. D. M. HENNIGAR, J. C. HIGGINS, MRS. G. WOOD.

(Continued at bottom of next page)

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

1890-1946

The Society was incorporated in 1890 under the name of The Astronomical and Physical Society of Toronto, and assumed its present name in 1903.

For many years the Toronto organization existed alone, but now the Society is national in extent, having active Centres in Montreal and Quebec, P.Q.; Ottawa, Toronto, Hamilton, London and Windsor, Ontario; Winnipeg, Man.; Edmonton, Alta.; Vancouver and Victoria, B.C. As well as nearly 1,200 members of these Canadian Centres, there are over 400 members not attached to any Centre, mostly resident in other nations, while some 50 additional institutions or persons subscribe to our publications.

The Society publishes a monthly "Journal" containing about 500 pages and a yearly "Observer's Handbook" of 80 pages. Single copies of the "Journal" or "Handbook" are 25 cents, postpaid. In quantities of 10 or more copies, the price is 20 cents a copy.

Membership is open to anyone interested in astronomy. Annual dues, $2.00; life membership, $25.00. Publications are sent free to all members or may be subscribed for separately. Applications for membership or publications may be made to the General Secretary, 3 Willcocks St., Toronto.

The Society has for Sale:

Reprinted from the "Journal" of the Royal Astronomical Society, 1936-1944.

The Physical State of the Upper Atmosphere, (revised 1941) by B. Haurwitz, 96 pages; Price 75 cents postpaid.

General Instruction for Meteor Observing, (revised 1940) by Peter M. Millman, 24 pages; Price 15 cents postpaid.

A Yoke Mounting for the Six-inch Telescope, by H. Boyd Brydon, 8 pages; Price 10 cents postpaid.

Setting Up and Adjusting the Equatorial Reflecting Telescope, by H. Boyd Brydon, 25 pages; Price 25 cents postpaid.

Occultations: their Prediction, Observation and Reduction, by H. Boyd Brydon, 76 pages, 1944; Price 60 cents.

In quantities of ten or more copies, a discount of 20 per cent will be allowed. Send Money Order to 3 Willcocks St., Toronto.

(Continued from previous page)

EDMONTON CENTRE

Honorary President—J. W. CAMPBELL
President—F. C. BLOWER
Vice-President—D. B. SCOTT
Secretary—E. H. GOWAN
Treasurer—MISS A. M. P. SMITH
Librarian—E. S. KEEPING
Council—W. WYMAN, A. J. FILMER, S. G. DEANE, H. A. MCGREGOR, W. E. MJOLSNESS.

QUEBEC CENTRE

Patron—MGR. FERDINAND VANDRY
Honorary President—ARTHUR AMOS, I.C.
President—J.-LUCIEN POULIOT, C.G.A.
First Vice-President—LIONEL LEMIEUX, B.A., LL.L.
Second Vice-President—GEO.-ETIENNE GAGNE
Secretary-Treasurer—PAUL-H. NADEAU
Council—JEAN-CHS. MAGNAN, B.A., B.SC.AG., L'ABBE ROSARIO BENOIT, L'ABBE EMILIEN GAUTHIER, ALBERIC BOIVIN, B.SC.AP., M-LOUIS CARRIER, I.C., CHARLES-A. GIROUX, LLOYD MCWILLIAMS, EL. E., OSCAR VILLENEUVE, I.F., PH.D., CLAUDE FREMONT.

WINDSOR CENTRE

Honorary President—E. R. PHELPS, PH.D.
President—CYRIL B. HALLAM, B.A.
Vice-President—DANIEL C. BAUTENHEIMER
Treasurer—CHARLES A. BELL, B.A.
Secretary—RUSSELL G. WARWICK, B.A.
Librarian—E. J. EDWARDS
Council—MRS. MARGARET BACK, HUGH S. CUNNINGHAM, B.A., ROBERT T. GRAHAM, B.T.C., W. ALMON HARE, B.A.SC., FREDERICK W. C. JONES, B.S., E. M. KREBSER, B.A.SC., HUGH MURRAY, B.A., WILLIAM J. PERSON, GREGORY RAWLINGS, B.A., LORNE R. ROGERS, B.A., W. A. ROBERSON, GERALD S. SPRACKLIN, GORDON E. TURNER and past president CAMERON H. MONTROSE, B.SC.